ANN BAVENDER*
ANNE GOODWIN CRUMP
VINCENT J. CURTIS, JR.
RICHARD J. ESTEVEZ
PAUL J. FELDMAN
ROBERT N. FELGAR*
RICHARD HILDRETH
FRANK R. JAZZO
ANDREW S. KERSTING*
EUGENE M. LAWSON, JR.
HARRY C. MARTIN
GEORGE PETRUTSAS
RAYMOND J. QUIANZON
LEONARD R. RAISH
JAMES P. RILEY
KATHLEEN VICTORY
HOWARD M. WEISS
* NOT ADMITTED IN VIRGINIA

FLETCHER, HEALD & HILDRETH, P.L.C.

ATTORNEYS AT LAW

11th FLOOR, 1300 NORTH 17th STREET
ARLINGTON, VIRGINIA 22209-3801

(703) 812-0400
TELECOPIER
(703) 812-0486
INTERNET
www.fhh-telcomlaw.com

FRANK U. FLETCHER
(1939-1985)
ROBERT L. HEALD
(1956-1983)
PAUL D. P. SPEARMAN
(1936-1962)
FRANK ROBERSON
(1936-1961)
RUSSELL ROWELL
(1948-1977)
EDWARD F. KENEHAN
(1960-1978)
CONSULTANT FOR INTERNATIONAL AND INTERGOVERNMENTAL AFFAIRS
SHELDON J. KRYS
U. S. AMBASSADOR (ret.)
OF COUNSEL
EDWARD A. CAINE*
MITCHELL LAZARUS*
EDWARD S. O'NEILL*
JOHN JOSEPH SMITH

WRITER'S DIRECT
730-812-0440
lazarus@fhh-telcomlaw.com

March 2, 1999

BY HAND DELIVERY
Terry G. Mahn, Esquire
Fish & Richardson P.C.
601 Thirteenth Street, NW
Washington, DC 20005

Dear Terry:

I am responding to your letter of February 5, which includes your notes from our January 14 meeting. At the meeting, Fusion representatives requested further information on technical characteristics of Part 15 spread spectrum equipment at 2.4 GHz.

The Part 15 companies that attended on January 14 tried to meet Fusion's requests with the materials I sent to your office on January 29. The package included a complete technical specification for IEEE 802.11, the wireless LAN protocol used at 2.4 GHz, and two recent technical articles dealing with interference into 2.4 GHz spread spectrum communications equipment.

You subsequently indicated that this information was inadequate. The language you quoted from your notes of the meeting was not helpful in identifying the particular questions to which Fusion is requesting answers. Accordingly, I proposed that the technical people from both industries meet in an attempt to clarify and respond to each other's informational needs. Such a meeting strikes me as a logical and unremarkable continuation of the process we began in January. Your letter of February 5, however, indicated that Fusion refuses to participate.

In a continuing effort to bring this matter to a negotiated resolution, the Part 15 and MSS interests listed below have prepared and endorsed two additional documents. One is an explanation of why our proposed in-band limit of 20 mv/m at 3m is the highest level that Part 15 communications equipment in the band can tolerate as a practical matter, and why even that level will inflict serious levels of interference on wireless LAN receivers operating in the band. The other document sets out an alternative plan under which RF lighting devices could operate at much higher emissions in some parts of the band

and lower emissions elsewhere. It is our intent that the uniform 20 mv/m limit and the alternative limits would both appear in the rules, and an RF lighting device would be considered to be in compliance if it met either set of limits.

I am authorized to state that the positions set out in these two papers are supported by the following entities:

AirTouch Communications, Inc.
Bluetooth Promoters (Ericsson, IBM, Intel, Nokia, and Toshiba)
Globalstar, L.P.
Harris Corporation
Metricom, Inc.
Symbol Technologies, Inc.
3Com Corporation

I look forward to hearing from you.

Sincerely,

Mitchell Lazarus

cc: David Jatlow, Esquire
Ray Martino, Symbol Technologies, Inc.
Carlos Rios, 3Com Corporation
Steve Sharkey, AirTouch
Larry Solomon, Esquire
Jim Zyren, Harris Corporation
Frank R. Jazzo, Esquire
Leonard R. Raish, Esquire

1.0 Abstract

This paper briefly describes the basis for the proposed 20 mV/m limit on in-band radiation for RF Lighting devices operating in the 2.45 GHz band. It will be demonstrated by means of a simple link analysis that the 20 mV/m limit is already at a level which will inflict serious levels of interference on WLAN receivers operating in the band.

The goal of the Part 15 interests is to minimize the negative impact of RF lighting devices on Part 15 communications equipment. It is therefore difficult, if not impossible, to arrive at an absolute threshold below which there will be no impact on Part 15 equipment. Rather, we seek to find a mutually agreeable limit on in-band emissions for RF lighting devices which is as low as reasonably achievable. The proposal put forward by the Part 15 interests represents a sincere effort to strike a balance between what is reasonably achievable by manufacturers of RF lighting devices and a level of interference which will minimize, but not completely eliminate, the negative impacts on the operation of Part 15 communications equipment.

2.0 Impact of Proposed 20 mV/m @ 3 m Limit on Wireless LAN Equipment

The sources of RF energy in the lighting devices in question are magnetrons which are similar, if not identical, to those used in consumer microwave ovens. The impact of emissions from consumer microwave ovens on Wireless LAN (WLAN) reliability has already been analyzed [1]. This analysis is based on the assumption that the magnetrons are driven by half wave rectified power supplies. Therefore, it is presumed that the RF emissions have only a 50% duty cycle.

2.1 EIRP of a Single Device Emitting at 20 mV/m @ 3 m

In order to estimate the impact of emissions from RF lighting devices operating at the proposed limit, the effective isotropic radiated power (EIRP) of the device must be computed:

$$\theta = |E|^2 / \eta_o$$

where:

θ = power flux density (W/m²)

E = magnitude of the E-field (V/m)

η_o = free space impedance (377 ohms)

In this instance:

$$\theta = [0.020^2] / 377 = 1.06 \times 10^{-6} \text{ W / m}^2$$

EIRP is determined by integrating power flux density over a sphere of 3 meter radius:

$$\text{EIRP} = 1.06 \times 10^{-6} \text{ W / m}^2 \times (4 \pi 3^2) = 1.2 \times 10^{-4} \text{ W} = -9 \text{ dBm}$$

2.2 Jammer Time & Frequency Profile

Based on the assumption that the magnetron is driven by a half wave rectified power supply, the magnetron can be thought of as a swept narrowband jammer [4,5,6]. The time/frequency profile of such a jammer is shown in Figure 2.2-1 below:

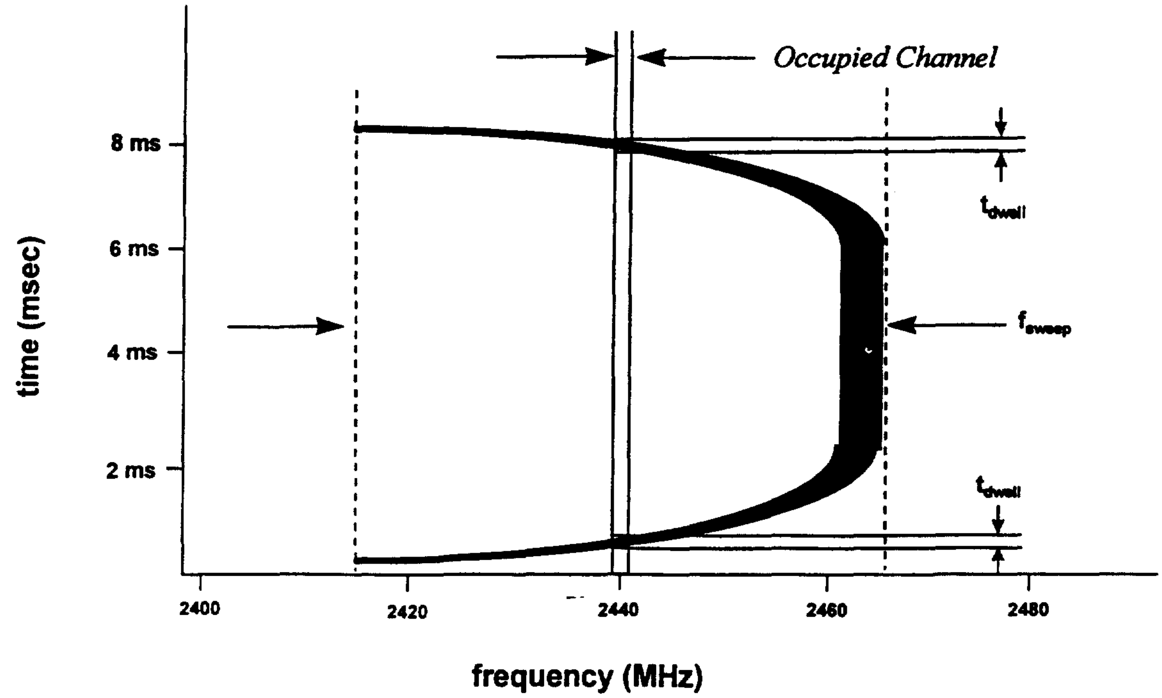


Figure 2.2-1 Time / Frequency Profile of RF Lighting Device Interference

2.3 *Impact on WLAN Reliabliltiy*

There are several variables which come into play when attempting to estimate the impact of this type of interference on WLAN reliability. They key parameters are:

a. Distance between the RF lighting device and the WLAN receiver
b. Distance between the WLAN transmitter and the WLAN receiver
c. Type of WLAN device (FHSS or DSSS), and the transmitted data rate
d. Output power of the WLAN transmitter
e. propagation model

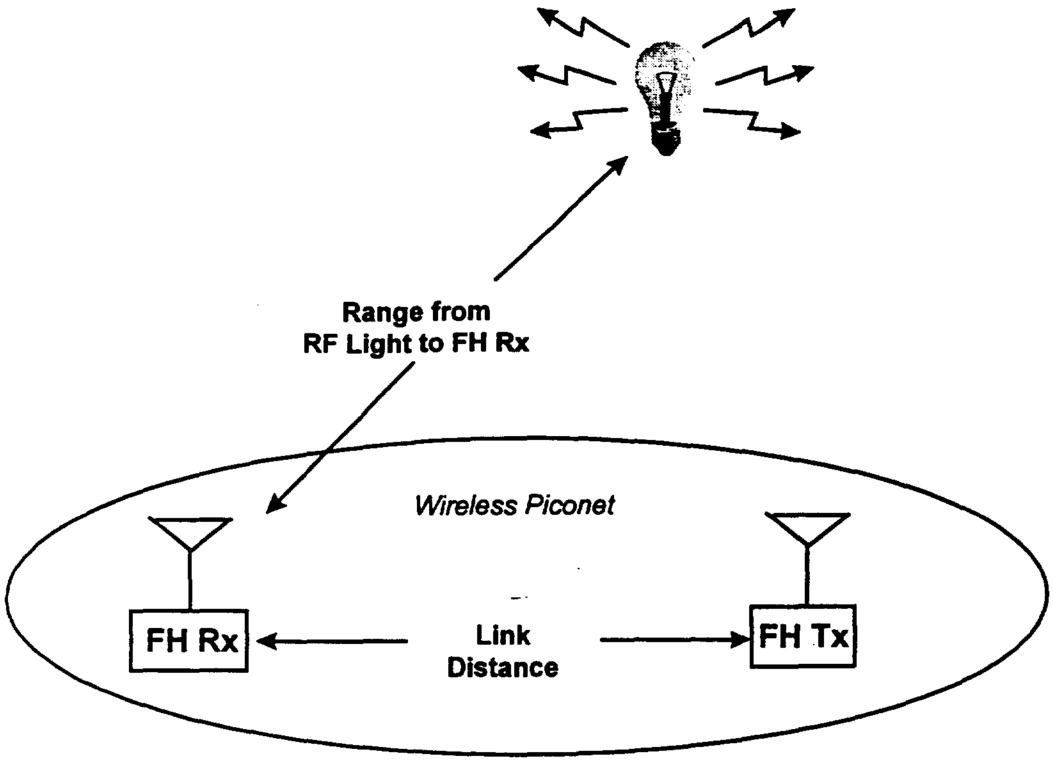


Figure 2.3-1 WLAN Reliability Affected by Link Distance and Separation from RF Light

For the purpose of this analysis, it is assumed:

a. RF output power of WLAN transmitter is 100 mW (+20 dBm) for both FHSS and DSSS systems
b. RF front ends of receivers remain linear

The second assumption means that the effects of intermodulation will be ignored. However, it must be pointed out that if the RF energy emitted by the lighting devices is too high, the front end of the WLAN receiver will enter into a non linear mode of operation. In this event, the WLAN receiver may become completely inoperative, regardless of the frequency to which it is tuned to within the 2.45 GHz ISM band.

The propagation model assumed is based on a Joint Test Committee (JTC) model which is commonly applied to indoor propagation. JTC is part of the International Telecommunications Union (ITU). The model:

$$\text{Lprop} = 40 \text{ dB} + 30 \log_{10} (\text{distance in meters})$$

This model may be interpreted to mean that propagation is line-of-sight (LOS) for the first meter (R^{-2}), then power falls off as the cube of distance thereafter. This model gives a reasonable first order approximation of the indoor environment. In the case of an interferor, LOS propagation is assumed because, unlike communication links, jammers are largely unaffected by channel distortion.

For an FHSS system transmitting 500 byte packets at 2 Mbps, approximately 22 dB SIR is required for reliable operation (PER < 10%) in the presence of microwave interference as described in Section 2.2 above [1]. Based on this data, the required separation from an RF light can be calculated, as shown in the example below:

Example: An FHSS WLAN station in the receive mode is located 30 meters from its corresponding transmitter. Based on the stated assumptions, what is the required separation, from an RF lighting device which will allow the FHSS system to achieve reliable operation ?

Transmitter and receiver antenna gain (Gtx , Grx):	0 dB (omnidirectional)
Transmitter power (Ptx):	+20 dBm
Interference power (Prx):	-9 dBm
Required SIR:	22 dB
Propagation loss (Lfs):	84 dB

Received signal strength:

$$\begin{aligned} Prx &= Ptx + Gtx + Grx - Lfs \\ &= 20dBm + 0\,dB + 0\,dB - 84\,dB \\ &= -64\,dBm \end{aligned}$$

Maximum tolerable Interference power:

$$\begin{aligned} Imax &= Prx - SIR \\ &= -64\,dBm - 22\,dB \\ &= -86\,dBm \end{aligned}$$

Required separation (meters) from an RF lighting device:

$$\begin{aligned} Lfs &= -9\,dBm - (-86\,dBm) \\ &= 77\,dB \end{aligned}$$

$$\begin{aligned} Separation &= 10^{(77/20)} * 0.1224 / 4 * pi \\ &= 70 \text{ meters} \end{aligned}$$

Required separation from a single RF light as a function of link distance is plotted in Figure 2.3-2. This discussion is fairly simplistic in that it largely neglects the effect of multipath and that of multiple RF lights operating within range of the receiver. In addition, the interaction between the interference generated by a half-wave rectified magnetron and a DSSS WLAN are somewhat different [1].

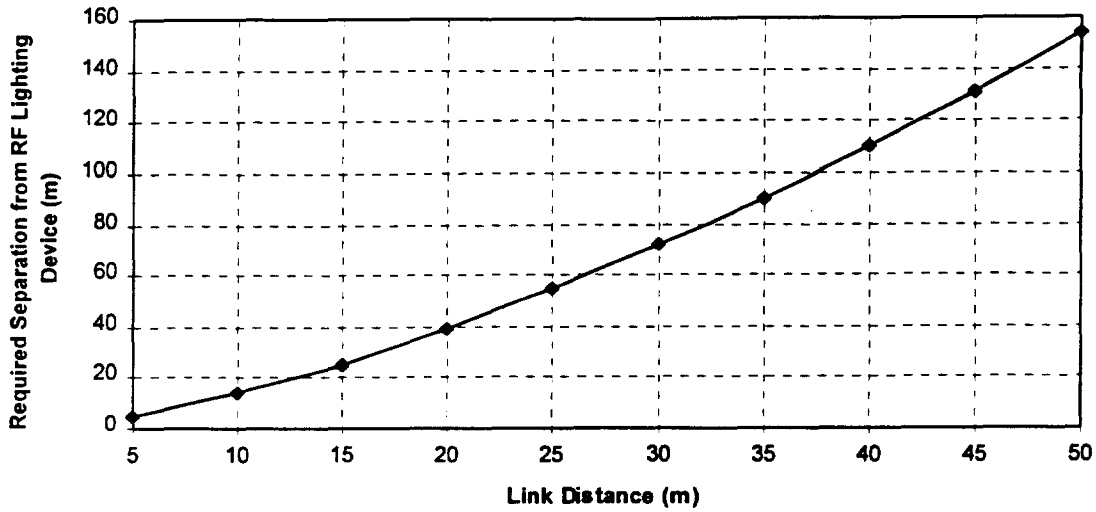


Figure 2.3-2 Required Separation of FHSS Receiver from RF Light

4.0 Conclusions

Based on the foregoing discussion, it is hopefully apparent that a limit of 20 mV/m @ 3m is already at a level which is sufficiently high to seriously affect the reliability of WLANs. However, if the promoters of RF lighting devices would agree in principle that the use of full wave rectified power supplies were a possibility, the interference profile would change considerably. There would be no voltage transients as the 60 Hz / 50 Hz power swept through each cycle. This would eliminate the swept nature of the narrowband interference. In this instance, the total bandwidth of a single device would be less than 1 MHz.

If in addition to the use of RF sources which are not swept in nature, the RF lighting promoters would agree to restrict emissions of all devices to some defined portion of the spectrum (eg 2475 MHz - 2480 MHz), then the issue of multiple RF lights operating in the band could be mitigated. The problem currently involves the fact that multiple lights, each acting as a swept narrow band jammer and possibly on separate phases of AC power could spread their energy over the entire 2.45 GHz ISM band.

Therefore, in the interest of promoting discussion on this difficult technical issue, we ask two questions of the promoters of RF lighting:

1.) Is the use of full-wave rectified power supplies in order to suppress voltage transients and thereby eliminate the swept nature of the magnetron generated interference a possibility?
2.) Even with narrowband interference, multiple devices operating in a given physical area would still effectively pose a broadband interference threat. Would it be possible to confine the area of unlimited operation to a narrow portion of the ISM spectrum (eg 5 MHz)?

If these two questions can be answered in the affirmative, limits which are higher than the 20 mV/m level now put forward by the Part 15 interests can be considered. If not, the effort required to investigate this possibility and generate a modified proposal is not warranted. Other methods will have to be explored.

References

1. Zyren, J.G., Harris Semiconductor, "Effects of Microwave Oven Interference on IEEE 802.11 WLAN Reliability", doc: IEEE P802.11-98/240, May 1998.

2. Gawthrop, F.H. Sanders, J.J. Sell, "Radio Spectrum Measurements of Individual Microwave Ovens", NTIA Report 94-303-1.

3. Gawthrop, F.H. Sanders, J.J. Sell, "Radio Spectrum Measurements of Individual Microwave Ovens", NTIA Report 94-303-2.

4. Horne, S. Vasudevan, "Modeling and Mitigation of Interference in the 2.4 GHz ISM Band", Applied Microwaves & Wireless, March/April 1997, pp. 59-71.

5. Jim McDonald, Motorola Inc., "Recommendations for 2.4 GHz Frequency Hop Packet or Fragment Length", IEEE Document P802.11-94/109, May 1994.

6. Kamerman, N. Erkocevic, "Microwave Oven Interference on Wireless LANs Operating in the 2.4 GHz ISM Band", The 8th International Symposium on Personal Indoor and Mobile Radio Communications, Helsinki, Finland, September 1997.

7. Robert C. Dixon, "Spread Spectrum Systems, 3rd Edition", John Wiley & Sons, 1994, pp. 36-44.

8. John G. Proakis, "Digital Communications, 2nd Edition", McGraw-Hill, 1989, pp. 851-859.

1.0 Introduction

The following paragraphs describe an alternative to the limit on in-band emissions of 20 mV/m @ 3 m for RF lighting devices already proposed by the Part 15 Interests. In an effort to provide the promoters of RF lighting devices with a viable alternative, it is proposed that a 5 MHz portion of the ISM band be reserved for higher powered emissions from RF lighting devices. It is further proposed that this band be located at 2478.5 - 2483.5 MHz. RF Lighting devices shall be restricted to the Part 15 Class A limit of 60 dBuV/m @ 3m in the remainder of the 2.45 GHz ISM band.

As described below, this new proposal represents an attempt to balance the competing interest of the promoters of RF lighting devices, manufacturers and users of WLAN equipment, and users of satellite services in the 2483.5 - 2500 MHz band.

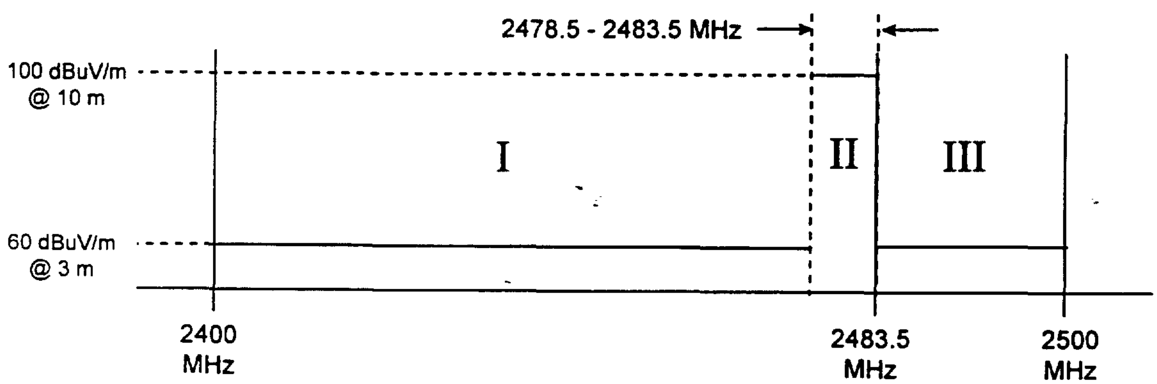
2.0 Proposed RF Lighting PSD

A proposed power spectral mask for RF lighting is shown in Figure 2.0-1 The 2400 - 2500 MHz ISM band is divided into three regions:

Region I: 2400 - 2478.5 MHz. This portion of the band has a limit of 60 dBuV/m @ 3 m, which is consistent with Part 15 Class A limits

Region II: 2478.5 - 2483.5 MHz. RF lighting emission limit in this region should be limited to 100 dBuV/m @ 10 m (equivalent to 330 mV/m @ 3m).

Region III: 2483.5 - 2500 MHz. Emissions limited to same level as Region I.



Region I : 2400 - 2478.5 MHz. RF lighting restricted to Part 15, Class A limit.

Region II : 2478.5 - 2483.5 MHz. RF Light emission limit of 100 dBuV/m @ 10 m (equivalent to 330 mVm @ 3m). Consistent with CISPR15 limits.

Region III : 2483.5 - 2500 MHz. RF lighting restricted to Part 15, Class A limit. This portion of the band includes satellite services.

Figure 2.0-1 Alternative Proposal for In-Band Emissions from RF Lights

3.0 Impact on Interested Parties

The proposed limit is technically feasible, but requires compromise by all interested parties. The magnetron sources used to excite the sulfurous light-emitting compound used in RF lighting devices are inherently ***narrowband*** devices. It is the use of half-wave rectified power supplies (and the associated voltage transients on every cycle of the sinusoidal voltage oscillation of the AC power line) which causes the magnetrons to sweep in frequency and spread interference over a wide portion of the ISM band.

3.1 RF Lighting Promoters

The limit of 100 dBuV/m (equivalent to 330 mV/m @ 3m) is consistent with the CISPR15 limit. This by itself is only of secondary importance. The main issue is that RF lighting interests have already built and sold devices in Europe which comply with this limit (though the CISPR 15 limit is 100 dBuV/m @ 10 m from 2400 - 2500 MHz).

Magnetrons are inherently narrowband devices. Even when loaded, the instantaneous bandwidth is only several hundred kilohertz wide. As described in numerous technical papers on the subject, magnetrons driven by half wave rectified power supplies have a 50% duty cycle and sweep over a considerable portion of the ISM band. Since multiple RF lights can be installed in a given site and could be powered from different phases of the AC power line voltage, these devices could collectively pose a continuous uninterrupted source of broadband interference. Via the use of full-wave rectified power supplies and restricting high powered emissions to a 5 MHz region of the band should effectively address the concerns of both WLAN manufacturers and satellite users.

3.2 Manufacturers of WLAN Equipment

There are two types of radios used in WLANs: Direct Sequence Spread Spectrum (DSSS) and Frequency Hopped Spread Spectrum (FHSS). The implications for each radio type differ slightly, and are described separately below.

3.2.1 DSSS

DSSS based LANs usually operate on three separate non-overlapping channels as shown in Figure 3.2.1-1. By locating a high powered source of RF interference in the 2478.5 - 2483.5 MHz region, DS LAN's may suffer from performance impairment when operating on Channel 11. However, the level of interference will be dependent on the relative location of the RF lighting devices to the WLAN transceivers. Further, DSSS WLAN's operating on Channel 11 in environments where co-location of RF lighting devices and WLAN equipment is essential could reduce the nominal data rate to 7 - 8 Mbps, and use a narrower channel width to provide improved immunity to interference from RF lights operating in the proposed 2478.5 - 2483.5 MHz band.

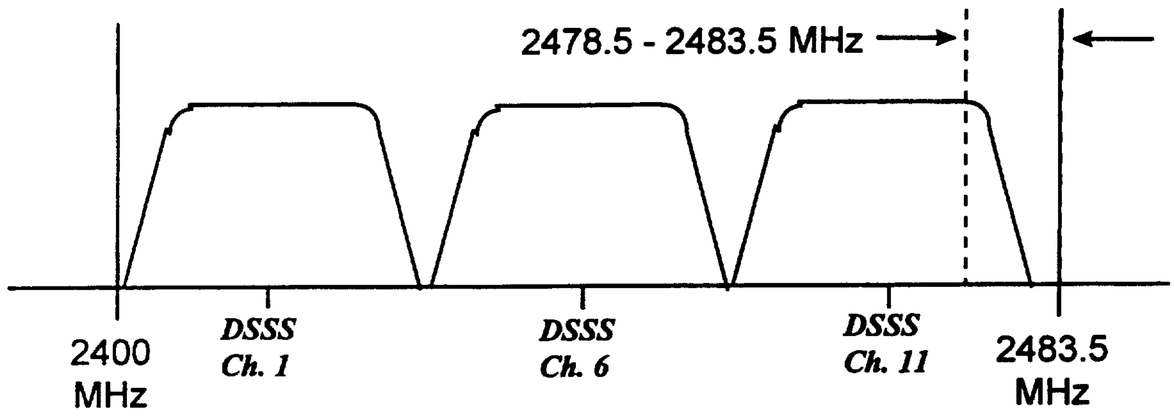


Figure 2.2.1-1 Proposed RF Lighting Band will Overlap DSSS Channel 11

3.2.2 FHSS

FHSS technology is used both for Bluetooth and IEEE 802.11 based WLAN systems. If a high powered source of fixed RF interference were located at the extreme lower edge of the proposed 2478.5 - 2483.5 MHz band, two FHSS channels, 79 and 80 (note that DSSS and FHSS channel definitions are different), would be affected. The degree to which these channels would be affected is dependent upon the relative locations of the RF lighting devices and the WLAN transceivers. However, it must be assumed that in some extreme circumstances, the use of Channels 79 and 80 may be precluded.

This level of interference may be deemed acceptable to manufacturers of FHSS equipment. If not, FCC regulations would permit modification of the hop sequence to eliminate channels 79 and 80. This would result in a system having only 77 separate FH channels, which still exceeds the FCC requirement for at least 75 channels (FCC 15.247).

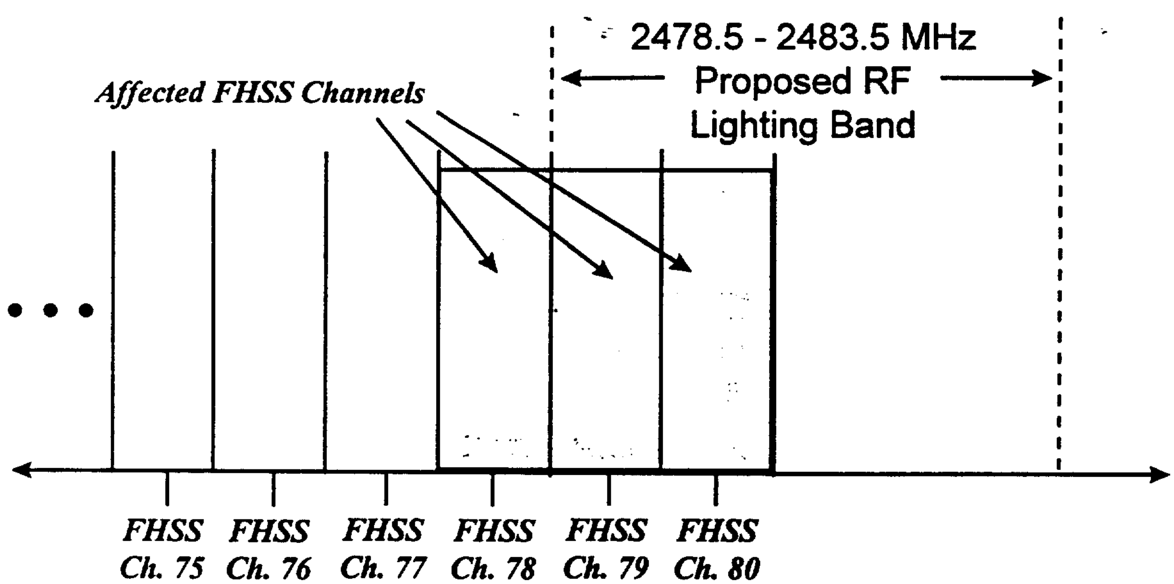


Figure 3.2-1 Proposed RF Lighting Band will Affect FHSS Channels 79 and 80

3.3 Satellite Terminals

The 2483.5 - 2500 MHz region of the ISM band is a restricted band for Part 15 users. This is due to location of satellite services in this spectrum. Nevertheless, the rule change now before the FCC would authorize RF lighting devices to radiate in this portion of the ISM band without limitation. The power spectral mask proposed herein addresses this issue. By locating the RF lightning band (radiation limit of 100 dBuV/m) in the 2478.5 - 2483.5 MHz region, none of the spectrum reserved for satellite services would be affected. The proposed power spectral mask protects the entire 2483.5 - 2500 MHz band by imposition of the Part 15 Class A limit (60 dBuV/m @ 3m).

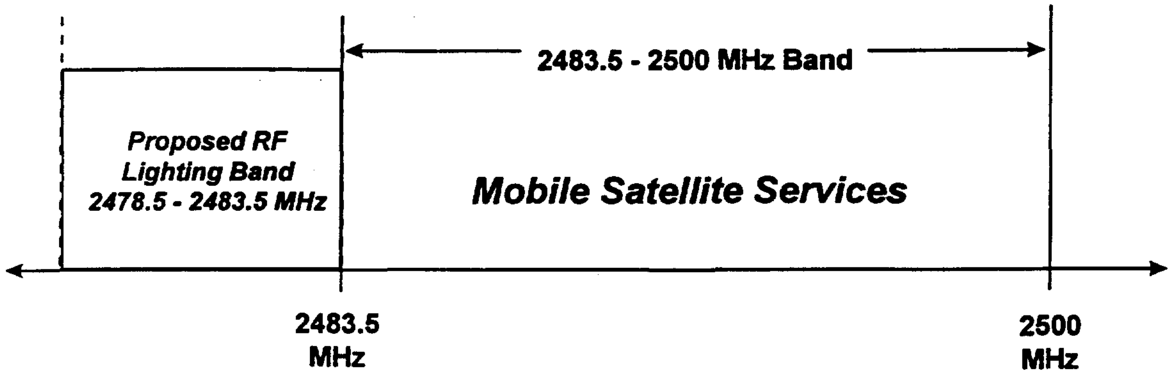


Figure 3.3-1 Proposed RF Light Band Overlaps 2483.5 - 2500 MHz Restricted Band

4.0 Conclusions

The proposed location for the RF lighting band (2478.5 - 2483.5 MHz) and the associated limit of 100 dBuV/m @ 10 m (equivalent to 330 mV/m @ 3m) represents a compromise for all interests. The Part 15 Interests will suffer from increased interference in the ISM band, but if the interference is contained within the proposed 5 MHz band, interference with both FH and DS based equipment would be minimized. At the same time, adoption of the limit will require manufacturers of RF lighting equipment to use full wave rectified power supplies.

This proposal represents a sincere attempt to balance the interests of all parties. We look forward to a response from the promoters of RF lighting devices in this matter and assure them that it will be given our prompt attention.

1.0 Abstract

This paper briefly describes the basis for the proposed 20 mV/m limit on in-band radiation for RF Lighting devices operating in the 2.45 GHz band. It will be shown that the limit is based on levels close to those which the RF lighting interests claim can already be met. It will also be demonstrated by means of a simple link analysis that the 20 mV/m limit is already at a level which will inflict serious levels of interference on WLAN receivers operating in the band.

The goal of the Part 15 interests is to minimize the negative impact of RF lighting devices on Part 15 communications equipment. It is therefore difficult, if not impossible, to arrive at an absolute threshold below which there will be no impact on Part 15 equipment. Rather, we seek to find a mutually agreeable limit on in-band emissions for RF lighting devices which is as low as reasonably achievable. The proposal put forward by the Part 15 interests represents a sincere effort to strike a balance between what is reasonably achievable by manufacturers of RF lighting devices and a level of interference which will minimize, but not completely eliminate, the negative impacts on the operation of Part 15 communications equipment.

2.0 Basis of Proposed 20 mV/m Limit on In-Band Emission

The Part 15 Interests have made at least two proposals regarding in-band emissions limits for RF lighting devices. The most recent proposal is based on data included in an ex parte filing by Terry Mahn made on behalf of Fusion Lighting on December 15, 1998. In that filing, Fusion Lighting states:

> *"Fusion lamps sold in Europe are 20 dB below IEC/CISPR Publication 15 limits for ISM band lighting (100 dBuV/m)"*

According to CISPR 15 (1996-03), the limit for emissions from RF lighting devices operating in the 2.45 GHz band is measured at 10 meters. This corresponds to:

CISPR 15 Limit:	100 dBuV/m @ 10 m
100 dBuV/m @ 10 m	= 100 mV/m @ 10 m
	= 330 mV/m @ 3 m

Based on statements from Fusion Lighting, devices currently being sold in Europe are 20 dB below this limit, which corresponds to an emission level of 33 mV/m @ 3 m. The proposed 20 mV/m @ 3m limit put forward by the Part 15 Interests therefore represents an emission level which is reasonably close to that which RF Lighting devices are emitting today. It should be noted that we have received no substantive comment on the proposed limit nor counter proposal to date.

3.0 Impact of Proposed 20 mV/m @ 3 m Limit on Wireless LAN Equipment

The sources of RF energy in the lighting devices in question are magnetrons which are similar, if not identical, to those used in consumer microwave ovens. The impact of emissions from consumer microwave ovens on Wireless LAN (WLAN) reliability has already been analyzed [1]. This analysis is based on the assumption that the magnetrons are driven by half wave rectified power supplies. Therefore, it is presumed that the RF emissions have only a 50% duty cycle. Information relating to the nature of emissions from RF lighting devices which would enable the accuracy of this crucial assumption to be verified has been requested from Fusion Lighting, but no information has been provided to date.

3.1 *EIRP of a Single Device Emitting at 20 mV/m @ 3 m*

In order to estimate the impact of emissions from RF lighting devices operating at the proposed limit, the effective isotropic radiated power (EIRP) of the device must be computed:

$$\theta = |E|^2 / \eta_o$$

where:

θ = power flux density (W/m^2)
E = magnitude of the E-field (V/m)
η_o = free space impedance (377 ohms)

In this instance:

$$\theta = [0.020^2] / 377 = 1.06 \times 10^{-6}\ \mathrm{W/m^2}$$

EIRP is determined by integrating power flux density over a sphere of 3 meter radius:

$$\mathrm{EIRP} = 1.06 \times 10^{-6}\ \mathrm{W/m^2} \times (4\pi 3^2) = 1.2 \times 10^{-4}\ \mathrm{W} = -9\ \mathrm{dBm}$$

3.2 *Jammer Time & Frequency Profile*

Based on the assumption that the magnetron is driven by a half wave rectified power supply, the magnetron can be thought of as a swept narrowband jammer [4,5,6]. The time/frequency profile of such a jammer is shown in Figure 3.2-1 below:

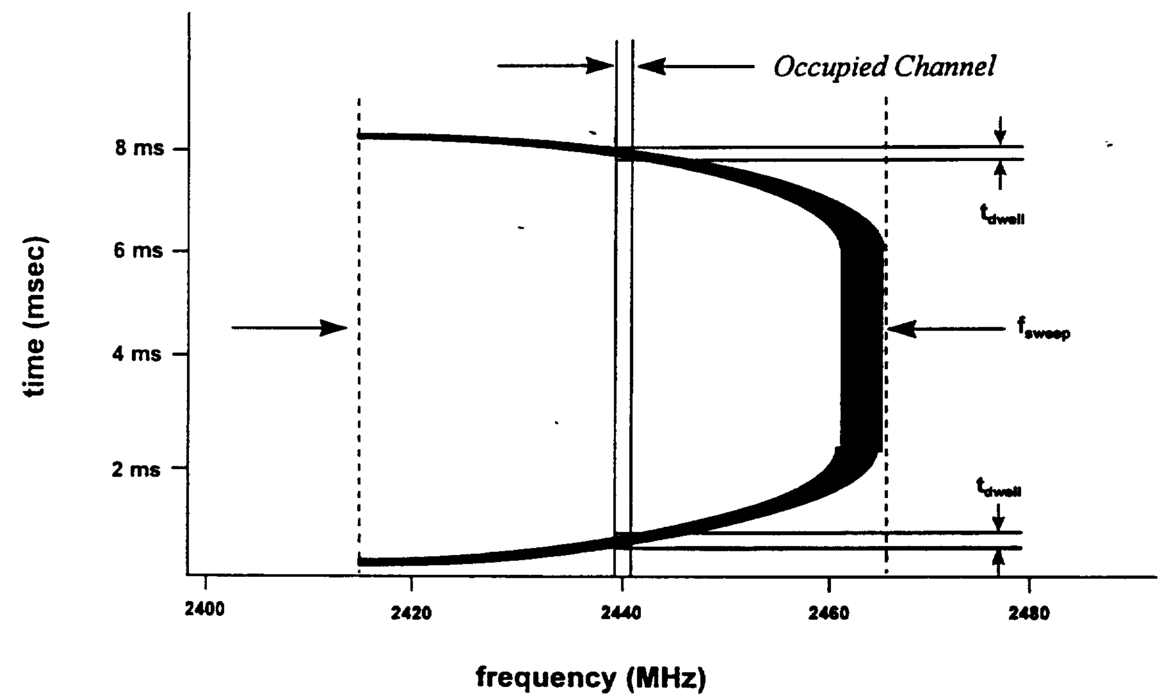


Figure 3.2-1 Time / Frequency Profile of RF Lighting Device Interference

3.3 Impact on WLAN Reliablility

There are several variables which come into play when attempting to estimate the impact of this type of interference on WLAN reliability. They key parameters are:

a. Distance between the RF lighting device and the WLAN receiver
b. Distance between the WLAN transmitter and the WLAN receiver
c. Type of WLAN device (FHSS or DSSS), and the transmitted data rate
d. Output power of the WLAN transmitter
e. propagation model

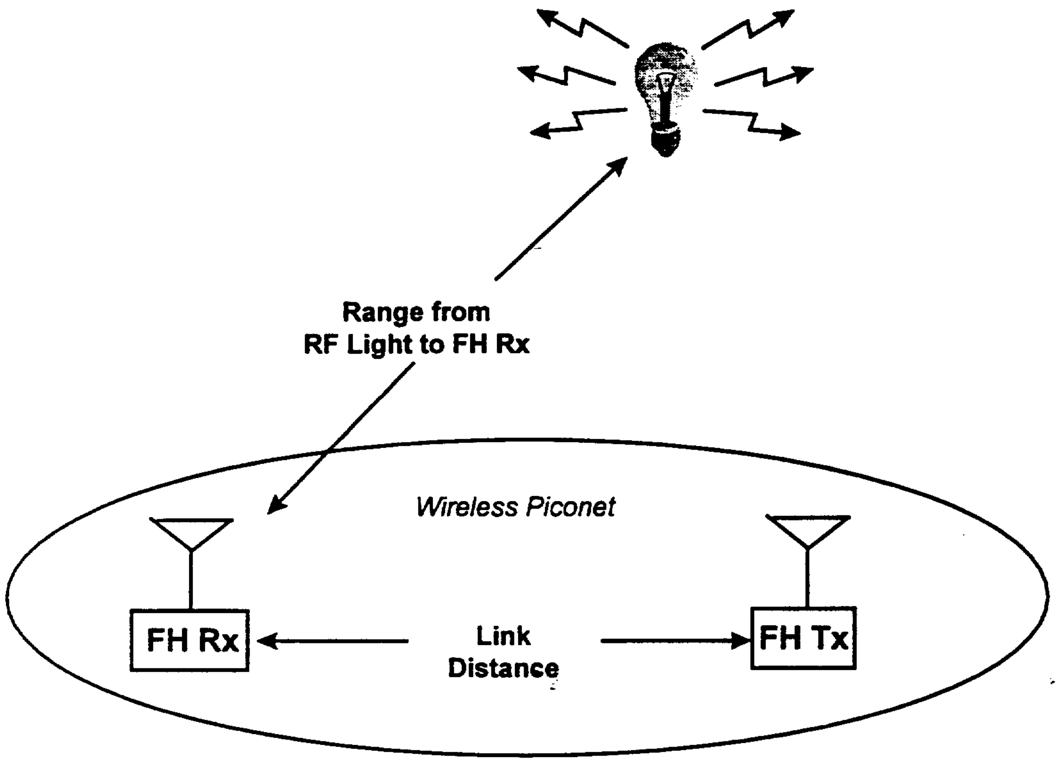


Figure 3.3-1 WLAN Reliability Affected by Link Distance and Separation from RF Light

For the purpose of this analysis, it is assumed:

a. RF output power of WLAN transmitter is 100 mW (+20 dBm) for both FHSS and DSSS systems
b. RF front ends of receivers remain linear

The second assumption means that the effects of intermodulation will be ignored. However, it must be pointed out that if the RF energy emitted by the lighting devices is too high, the front ends of the WLAN receivers will enter into a non linear mode of operation. In this event, the WLAN receiver may become completely inoperative, regardless of the frequency to which it is tuned to within the 2.45 GHz ISM band.

The propagation model assumed is based on a Joint Test Committee (JTC) model which is commonly applied to indoor propagation. JTC is part of the International Telecommunications Union (ITU). The model:

$$\text{Lprop} = 40\text{ dB} + 30\log_{10}(\text{distance in meters})$$

This model may be interpreted to mean that propagation is line-of-sight (LOS) for the first meter (R^{-2}), then power falls off as the cube of distance thereafter. This model gives a reasonable first order approximation of the indoor environment. In the case of an interferor, LOS propagation is assumed because, unlike communication links, jammers are largely unaffected by channel distortion.

For an FHSS system transmitting 500 byte packets at 2 Mbps, approximately 22 dB SIR is required for reliable operation (PER < 10%) in the presence of microwave interference as described in Section 3.2 above [1]. Based on this data, the required separation from an RF light can be calculated, as shown in the example below:

Example: An FHSS WLAN station in the receive mode is located 30 meters from its corresponding transmitter. Based on the stated assumptions, what is the required separation, from an RF lighting device which will allow the FHSS system to achieve reliable operation ?

Transmitter and receiver antenna gain (Gtx , Grx):	0 dB (omnidirectional)
Transmitter power (Ptx):	+20 dBm
Interference power (Prx):	-9 dBm
Required SIR:	22 dB
Propagation loss (Lfs):	84 dB

Received signal strength:

$$\begin{aligned} \text{Prx} &= \text{Ptx} + \text{Gtx} + \text{Grx} - \text{Lfs} \\ &= 20\text{dBm} + 0\text{ dB} + 0\text{ dB} - 84\text{ dB} \\ &= -64\text{ dBm} \end{aligned}$$

Maximum tolerable Interference power:

$$\begin{aligned} \text{Imax} &= \text{Prx} - \text{SIR} \\ &= -64\text{ dBm} - 22\text{ dB} \\ &= -86\text{ dBm} \end{aligned}$$

Required separation (meters) from an RF lighting device:

$$\begin{aligned} \text{Lfs} &= -9\text{ dBm} - (-86\text{ dBm}) \\ &= 77\text{ dB} \end{aligned}$$

$$\begin{aligned} \text{Separation} &= 10^{(77/20)} * 0.1224 / 4 * \text{pi} \\ &= 70\text{ meters} \end{aligned}$$

Required separation from a single RF light as a function of link distance is plotted in Figure 3.3-2. This discussion is fairly simplistic in that it largely neglects the effect of multipath and that of multiple RF lights operating within range of the receiver. In addition, the interaction between the interference generated by a half-wave rectified magnetron and a DSSS WLAN are somewhat different [1].

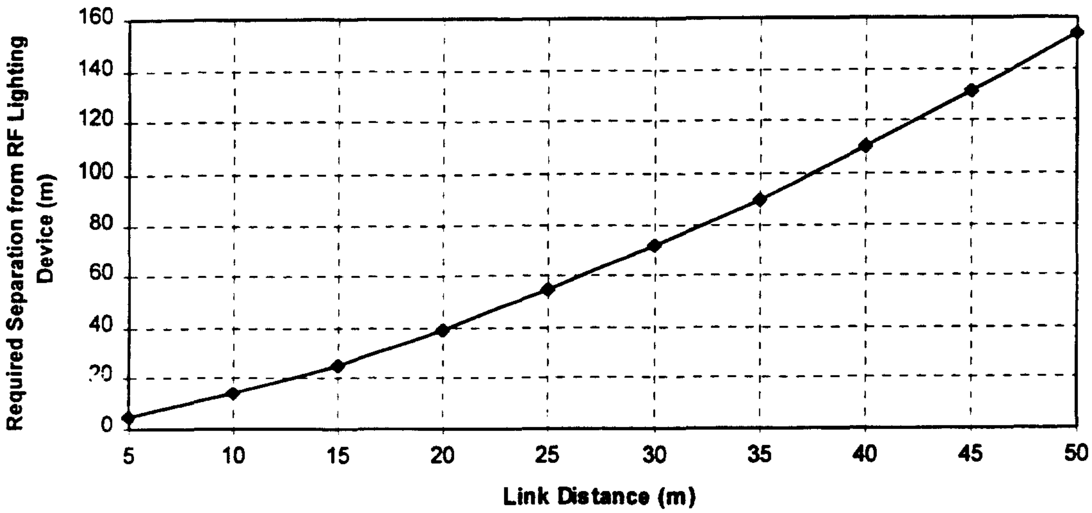


Figure 3.3-2 Required Separation of FHSS Receiver from RF Light

4.0 Conclusions

Based on the foregoing discussion, it is hopefully apparent that defining a hard limit below which all Part 15 users can operate is difficult, if not impossible. However, if the promoters of RF lighting devices would agree in principle that the use of full wave rectified power supplies were a possibility, the interference profile would change considerably. There would be no voltage transients as the 60 Hz / 50 Hz power swept through each cycle. This would eliminate the swept nature of the narrowband interference. In this instance, the total bandwidth of a single device would be less than 1 MHz.

If in addition to the use of RF sources which are not swept in nature, the RF lighting promoters would agree to restrict emissions of all devices to some defined portion of the spectrum (eg 2475 MHz - 2480 MHz), then the issue of multiple RF lights operating in the band could be mitigated. The problem currently involves the fact that multiple lights, each acting as a swept narrow band jammer and possibly on separate phases of AC power could spread their energy over the entire 2.45 GHz ISM band.

Therefore, in the interest of promoting discussion on this difficult technical issue, we ask two questions of the promoters of RF lighting:

1.) Is the use of full-wave rectified power supplies in order to suppress voltage transients and thereby eliminate the swept nature of the magnetron generated interference a possibility?
2.) Even with narrowband interference, multiple devices operating in a given physical area would still effectively pose a broadband interference threat. Would it be possible to confine the area of unlimited operation to a narrow portion of the ISM spectrum (eg 5 MHz)?

If these two questions can be answered in the affirmative, limits which are higher than the 20 mV/m level now put forward by the Part 15 interests. If not, the effort required to investigate this possibility and generate a modified proposal is not warranted. Other methods will have to be explored.

References

1. Zyren, Harris Semiconductor, "Effects of Microwave Oven Interference on IEEE 802.11 WLAN Reliability", doc: IEEE P802.11-98/240, May 1998.

2. Gawthrop, F.H. Sanders, J.J. Sell, "Radio Spectrum Measurements of Individual Microwave Ovens", NTIA Report 94-303-1.

3. Gawthrop, F.H. Sanders, J.J. Sell, "Radio Spectrum Measurements of Individual Microwave Ovens", NTIA Report 94-303-2.

4. Horne, S. Vasudevan, "Modeling and Mitigation of Interference in the 2.4 GHz ISM Band", Applied Microwaves & Wireless, March/April 1997, pp. 59-71.

5. Jim McDonald, Motorola Inc., "Recommendations for 2.4 GHz Frequency Hop Packet or Fragment Length", IEEE Document P802.11-94/109, May 1994.

6. Kamerman, N. Erkocevic, "Microwave Oven Interference on Wireless LANs Operating in the 2.4 GHz ISM Band", The 8th International Symposium on Personal Indoor and Mobile Radio Communications, Helsinki, Finland, September 1997.

7. Robert C. Dixon, "Spread Spectrum Systems, 3rd Edition", John Wiley & Sons, 1994, pp. 36-44.

8. John G. Proakis, "Digital Communications, 2nd Edition", McGraw-Hill, 1989, pp. 851-859.

FISH & RICHARDSON P.C.

601 Thirteenth Street N.W.
Washington, DC 20005

Telephone
202 783-5070

Facsimile
202 783-2331

Web Site
www.fr.com

Frederick P. Fish
1855-1930

W.K. Richardson
1859-1951

BOSTON
NEW YORK
SILICON VALLEY
SOUTHERN CALIFORNIA
TWIN CITIES
WASHINGTON, DC

March 12, 1999

Via Facsimile
(703) 812-0486

Mitchell Lazarus, Esq.
Fletcher Heald & Hildreth, P.L.C.
1300 North 17th Street
11th Floor
Rosslyn, VA 22209-3801

Re: Our File 07330/008001

Dear Mitch:

Thank you for your letter of March 2, 1999, providing additional materials to those which had been promised by the Part 15 Interests during our meeting on January 14, 1999. These appear to be substantially better focused on the issues under discussion than were the publications forwarded on January 29, 1999.

To clear up any possible misunderstanding, please be advised that Fusion did not refuse to meet with technical people from the Part 15 industry as you appear to suggest. Rather, Fusion merely indicated that further meetings would not be a productive use of resources until the Part 15 Interests had honored their commitment to supply answers to the technical questions raised at the January 14th meeting. Fusion engineers are now carefully studying the materials just received and have asked me to request clarifications, or answers, to the following questions:

1. Is the proposed 20m V/m @3m limit a peak or average measurement? Please specify the measurement methodology you would expect a manufacturer to use when measuring an RF lighting device. If the proposed limit is average, is there some absolute peak measurement which the Part 15 equipment cannot tolerate regardless of the average?

2. Please discuss the effect on your calculations of any non-isotropic emissions by an RF lighting device caused, for example, by a reflector that produces a gain (in the directions of the lighting) of 3, 6, 10 and 20 dB.

3. In your alternative proposal, you select 2.48 GHz (approximately) as the center frequency of a 5 MHz band in which to relax the 20m V/m @ 3m restriction on RF lighting devices. Are there any other locations in the 2.45 kHz ISM band where this center frequency could be located? Please explain.

4. Why do you seek much greater spectrum access for your purpose in the United States than IEEE standards indicate would suffice in most developed regions of the world? (See IEEE Standard 802.11: Section 14.6.3, Table 36, Section 14.6.4, Table 37; and Section 15.4.6.2, Table 63, among others).

5. Your proposed restriction on RF lighting devices presumably would allow the satisfactory performance of each of the various technologies that the members of your group promote. What lesser restriction would allow the least demanding of those technologies to perform satisfactorily? Please explain.

6. Why is the ISM band at 5.8 GHz inappropriate for the Part 15 Interests purposes? Can you provide cost estimates of developing equipment and operating Part 15 services in this band as compared to the 2.45 GHz band?

As soon as Fusion has had an adequate opportunity to review the information provided, including the responses to the foregoing questions, it will be in a position to meet again with the Part 15 Interests.

Please contact me at your convenience if you have any questions in this matter.

Very truly yours,

Terry G. Mahn

/seg
cc: Fusion Lighting, Inc.

96288.W11